



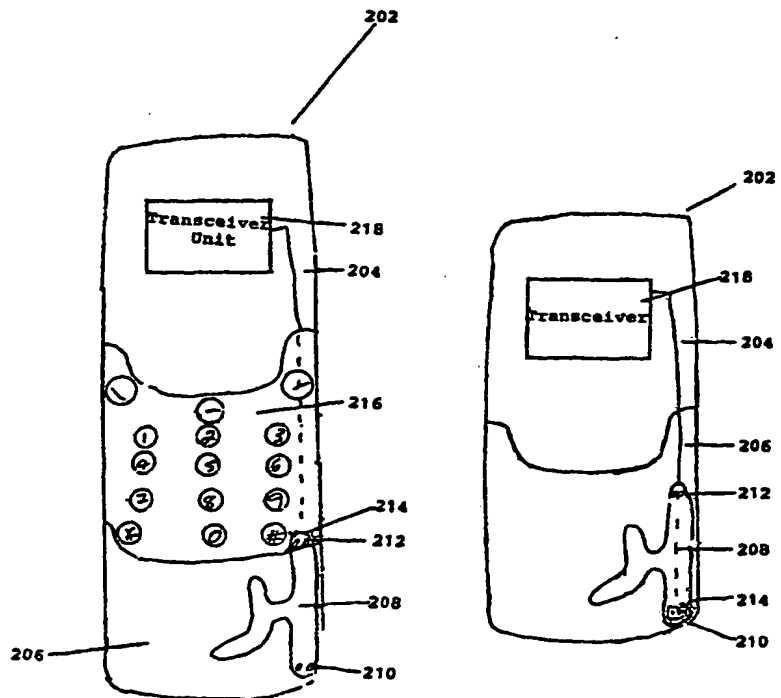
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(71) Applicant (for all designated States except US): <b>NOKIA MOBILE PHONES LIMITED [FI/FI]; Keilalahdentie 4, FIN-02150 Espoo (FI).</b>			
(72) Inventor; and (75) Inventor/Applicant (for US only): <b>YLIJURVA, Anitta [FI/US]; 1125 Normandy Drive, Grapevine, TX 76051 (US).</b>			
(74) Agent: <b>RIVERS, Brian; Nokia Inc., 6000 Connection Drive, 1-4-755, Irving, TX 75039 (US).</b>		Published With international search report.	

(54) Title: SLIDE MOUNTED ANTENNA

## (57) Abstract

A structure and method for minimizing adverse effects on the performance characteristics of an antenna in a wireless communications device caused by user interference. An electrically symmetrical microstrip antenna (208) is positioned internal to the body of the wireless device (202). When the device is closed (in a passive state) the antenna (208) is connected to the transceiver at one of the electrically symmetrical ends (210). When the device (202) is opened and more likely to be subject to user interference due to proximity of the hand or body to the device, the antenna (208) is connected to the transceiver at the other electrically symmetrical end (212). Shifting the connection point of the antenna (208) allows the antenna to be relocated to a position that is less likely to be subject to adverse effects caused by body proximity. In another embodiment, two microstrip antennas (302) and (308) are positioned at opposite ends, and internal to, the casing of the wireless device (202). An antenna switch (306) is used to control which antenna is connected to the transceiver unit at any given time. When the device (202) is closed, the switch can connect the antenna with the better signal (usually the antenna closest to the transceiver (308) to the transceiver (218). When the device is opened, the switch can connect the antenna least affected by user interference (302) to the transceiver unit (218).



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## SLIDE MOUNTED ANTENNA

Field of the Invention

5 This invention relates to antennas and, more particularly, to antenna placement in a cellular phone.

Background of the Invention

10 Antennas are generally used for transmission and reception of electromagnetic waves. An antenna operates by converting electrical current to (transmission) and from (reception) electromagnetic waves. One measure of antenna performance is "gain". Gain is based on the directivity and efficiency of the antenna. Directivity is an antenna's ability to focus energy in a desired direction. If desired, energy can be focused into a narrow beamwidth. This focused energy gives the ability to communicate over great distances, but as the angle of the antenna changes, the direction of the beam also changes, thus requiring proper orientation of the antenna for a good signal. Efficiency of an antenna concerns the amount of dissipative loss associated with the reception of a particular signal. Antennas can be designed in many different ways depending on their intended use. In cellular communications, for example, an antenna is designed for maximal "gain" at a particular frequency. Such a design is conventionally accomplished by constructing an antenna that is a fraction of the wavelength of the desired operating frequency.

20 The antennas used in mobile stations for cellular communications, are generally small, both electrically and physically. The size of the antenna is generally a function of the communication device itself, which is usually worn on the body or held in the hand of the user. Internal antennas for mobile stations offer an advantageous form factor that is convenient for slipping the device in a pocket or purse. External antennas increase the length of a mobile station and often snag when the device is being removed from, or returned to, a pocket or purse. However, when using an internal antenna, reception and transmission may be hindered by various factors. One hindrance of particular concern in cellular communications, is interference by a mobile station user's body. Such interference usually occurs due to placement of the user's head or hands between the mobile station and a base station.

30 The user's body causes a type of interference, known as "body effect". Body effect occurs because the human body conducts electromagnetic waves away from the mobile station's transceiver. In the case of cellular telephones, this effect is intensified because of the user's close proximity to the mobile station antenna. For example, it is common to see a mobile station user covering part of the antenna with his hand when using the telephone.

35

When the user grips the mobile station, the hand effectively becomes part of the ground plane of the antenna. The resulting change in size of the ground plane can adversely affect the performance characteristics of the antenna. Effects on the antenna can include, for example, frequency response shifts and decreased efficiency (including significant loss of signal).

In addition to holding the mobile station, many users rest their fingers on the external antenna when using the mobile station, further increasing signal loss. For example, at frequencies of interest to cellular communications, the user can cause a drop in gain of 5 to 20 dB or more by covering the antenna with his hand

A microstrip, or "patch," antenna consists of a square of dielectric material, for example, ceramic, plated with a smaller area of metal. Patch antennas require a ground plane. In theory, the ideal ground plane for a patch antenna is of infinite size. Practically, the ground plane should be significantly larger than the patch itself. Performance of the antenna is directly correlated to the size of the antenna and relative size of ground plane. **Figure 1** depicts an example of a microstrip antenna. The antenna comprises a patch antenna surface **102** and a ground plane surface **104** roughly the same size as the antenna surface. A dielectric material **106** is arranged between the patch and the ground plane.

In general, microstrip antennas are known for their advantages in terms of light weight, flat profiles, low manufacturing cost, and compatibility with integrated circuits. The most commonly used microstrip antennas are the conventional half-wavelength and quarter-wavelength rectangular patch antennas. Other microstrip antenna configurations have been studied and reported in the literature, such as circular patches, triangular patches, ring microstrip antennas, and the above-mentioned C-patch antennas.

There is a growing interest in developing efficient internal integrated antennas for wireless communications devices, for example, mobile stations. A high performance built-in antenna is required to have a very small size, a compact structure, a wide bandwidth, a quasi-isotropic radiation pattern, and to exhibit a negligible susceptibility to the proximity of the human body. Since mobile stations are normally randomly orientated during use, their antennas must be sensitive to both vertically and horizontally polarized waves. External antennas, such as the whip, sleeve dipole, and helical, are sensitive only to one polarization of the radio waves. As a result, they are not optimized for use with the mobile stations in which antenna orientation is not fixed. Moreover, it has been found that when such external antennas are operated in close proximity to a user of the phone, their radiation patterns can change significantly.

The microstrip antenna is one of the most preferable antenna types for small, portable wireless communication devices, particularly when a built-in antenna is required. Since the microstrip antenna can be made with a very thin and compact structure, it can easily match various types of wireless units.

Other features of antennas for mobile stations are contained in the U.S. Patent Application entitled "Antenna for Mobile Communications Device"; SN 09/005,103; filed 9 Jan. 1998, which is hereby incorporated by reference.

Additional general background, which helps to show the knowledge of those skilled in the art regarding the system context, and of variations and options for implementations, may be found in the following: Brodsky, Wireless: The Revolution in Personal Telecommunications (1995); Harte, et al., GSM Superphones (1999); Lee, Mobile Cellular Telecommunications (1995); Siwiak, Radiowave Propagation and Antennas for Personal Communications (1998); and Webb, Understanding Cellular Radio (1998); all of which are hereby incorporated by reference.

#### Summary of the Invention

The disclosed embodiments of present application provide a structure and a method for minimizing adverse effects on the performance characteristics of an antenna in a wireless communications device caused by user interference. In one embodiment, an electrically symmetrical microstrip antenna is positioned internal to the body of the wireless device. When the device is closed (in a stand-by state) the antenna is connected to the transceiver at one of the electrically symmetrical ends. When the device is opened and more likely to be subject to user interference due to proximity of the hand or body to the device, the antenna is connected to the transceiver at the other electrically symmetrical end. Shifting the connection point of the antenna allows the antenna to be relocated to a position that is less likely to be subject to adverse effects caused by body proximity.

In another embodiment, two microstrip antennas are positioned at opposite ends, and internal to, the casing of the wireless device. An antenna switch is used to control which antenna is connected to the transceiver unit at any given time. When the device is closed, the switch connects the antenna with the better signal (usually the antenna closest to the transceiver) to the transceiver. When the device is opened, the switch connects the antenna least affected by user interference to the transceiver unit.

The disclosed embodiments provide several advantages. For example, improved antenna gain is achieved due to dynamic location of an internal antenna. The amount of signal loss due to the mobile station user's body being in proximity to the wireless device is reduced. Reliability of communications is improved due to the ability of the mobile station to

connect to an antenna with better gain. Signal loss due to the mobile station user's fingers resting on an external antenna is eliminated. Compliance with FCC specific absorption ratio (SAR) regulations is more easily accomplished. Finally, the mobile station and its user are protected from antenna damage due to snagging of an external antenna.

#### Brief Description of the Drawings

The disclosed innovations will be described with reference to the accompanying drawings, which show important sample embodiments of the invention and which are incorporated in the specification hereof by reference, wherein:

**Figure 1** depicts an example of a prior art microstrip antenna.

**Figures 2A and 2B** depict a mobile station with a slide-type cellular phone casing having an internal electrically symmetrical microstrip antenna.

**Figure 3** depicts a slide-type cellular phone casing for a mobile station with more than one internal antenna.

**Figure 4** depicts a mobile station with a slide-type cellular phone casing having an internal electrically symmetrical microstrip antenna.

**Figure 5** depicts a block diagram of a mobile station that can make use of the disclosed embodiments.

#### Detailed Description of the Preferred Embodiments

The numerous innovative teachings of the present application will be described with particular reference to the presently preferred embodiments. However, it should be understood that this class of embodiments provides only a few examples of the many advantageous uses of the innovative teachings herein. In general, statements made in the specification of the present application do not necessarily delimit any of the various claimed inventions. Moreover, some statements may apply to some inventive features but not to others.

**Figures 2A and 2B** depict a mobile station with a movable-type cellular phone casing **202** which includes an internal electrically symmetrical microstrip antenna. A movable-type casing is typified in that a moveable portion of the case **206** must be moved for the user to access some functions of the device. In the presently preferred embodiment, the casing **202** is a slide-type casing. In the presently preferred embodiment, device functions are generally accessed through the numeric keypad and other control keys **216**. These keys **216** are positioned in the stationary portion of the case **204**. The movable portion of the case **206** typically contains a microphone. Moving the movable portion of the

case 206 to the open position generally moves the microphone to a position that offers better pickup of the user's voice.

Figure 2A depicts a mobile station with a slide-type cellular phone casing 202 which is closed. In the presently preferred embodiment, the movable portion of the casing 206 covers the keyboard 216 when the casing 202 is closed. Most device functions are not user-accessible while the casing is closed. When closed, the mobile station may be on or off. When turned on, the mobile station is registered on a wireless network, if available, and searching for pages or other information. Generally, with this type of casing 202, the mobile station is considered in stand-by mode when it is closed and on. When in stand-by mode, the user cannot initiate communications.

In the presently preferred embodiment, the antenna 208 of the mobile station is located internal to the casing 202, in its movable portion 206. An electrically symmetrical microstrip (or stripline) antenna is used in the presently preferred embodiment. An electrically symmetrical microstrip antenna has more than one tap (or contact) point available that will yield the same antenna load and characteristics to a connected transceiver unit 218. That is, changing tap points between electrically symmetrical tap points does not change the mode (or frequency) in which the mobile station operates. However, the physical shape of such an antenna is not necessarily symmetrical. In the presently preferred embodiment, the tap points of the antenna 210 and 212 are at upper and lower ends of the antenna 208, with respect to the cellular casing 202. When the cellular casing is closed, the antenna 208 is connected to the transceiver unit 218 at the lower tap point 210. The connection to the transceiver unit 218 can be accomplished by an antenna connector 214 fixed to the stationary portion of the case 204.

Figure 2B depicts the slide-type cellular phone casing 202 of the mobile station open and ready for user interface. The keyboard 216 is exposed by the movable portion of the case 206 being slid downward relative to the stationary portion of the cellular casing 204. In the presently preferred embodiment, opening the cellular casing moves the antenna 208, which is internal to the movable portion of the case 206, downward relative to the antenna connector 214. The movement of the antenna 208, which is fixed in the movable portion of the casing 206, relative to the antenna connector 214, which is fixed in the stationary portion of the casing, causes the tap point of the antenna 208 to change. Moving the antenna downward changes the antenna connection to the transceiver unit 218 from the lower tap point 210 to the upper tap point 212. The movement of the antenna 208 relative to the stationary portion of the case 204 shifts it farther away from the stationary portion of the

casing 204. Since this movement occurs when the casing 202 is open and therefore more likely to be affected by user interference, the amount of signal loss is reduced.

5 **Figure 3** depicts a mobile station with a slide-type cellular phone casing having more than one internal antenna according to an alternative embodiment. The casing 202, with stationary 204 and movable 206 portions, and a user interface keyboard 216 operate as described in Figures 2A and 2B. The cellular casing of Figure 3 is configured with two internal antennas, a lower antenna 302 which is located in the movable portion 206 of the casing 202 and an upper antenna 308, which is located in the top of the stationary portion 10 204 of the casing 202.

Each antenna is connected to an antenna switch 306 located in the stationary portion 204 of the casing 202. The lower antenna 302 is connected (hardwired) at a single tap point 304. The connection of the lower antenna 302 to the antenna switch 306 should be of a material with enough length to allow the movable portion 204 of the cellular casing 202 to open without breaking or significantly stressing the antenna connection 304. The 15 connection material should also be flexible enough to withstand the repeated opening and closing of the movable portion 204 of the casing 202. The upper antenna 308 is also hardwired to the antenna switch at a single tap point.

The antenna switch 306 controls which antenna is connected to the transceiver unit 20 218. The antenna switch 306 can be mechanically (or electrically) operated. Sliding the casing 202 open would operate (or trigger the operation of) the antenna switch, changing the antenna connected to the receiver from the upper antenna 308 to the lower antenna 302. Switching to the lower antenna when the case is open shifts the transceiver unit 218 functions of transmitting and receiving farther away from the stationary portion of the casing. 25 Since this switching occurs when the casing 202 is open and therefore more likely to be affected by user interference, the amount of signal loss is reduced.

**Figure 4** depicts a mobile station with a slide-type cellular phone casing having an internal microstrip antenna according to an alternative embodiment. In the alternative embodiment of Figure 4, the transceiver unit 218 can be connected (hardwired) to the 30 antenna 208 at only one tap point 212 rather than switching between two tap points as depicted in Figures 2A and 2B (210 and 212). The connection to the transceiver unit 218 should be flexible enough (or have room inside the casing 202) and long enough to allow the movable portion of the casing 206 to fully open. A material such as a stripline, insulated copper wire, or coaxial cable can be used to make a connection to the transceiver unit 218.



Alternatively, the connection can have an intermediate connector to facilitate the transfer of the antenna signal between the movable and stationary portions of the casing.

A casing 202 in the alternative embodiment of Figure 4 can also be manufactured to open by pivoting (or flipping) away from the stationary portion of the case 204. Pivoting can be to the outside of the casing 202, relative to the user, or above or below the casing 202

In another alternative embodiment, a digital signal processor (DSP), taking the place of antenna switch 306 in Figure 3, can be connected to receive signals from both antennas 302 and 308. The DSP can evaluate signal quality and dynamically switch the transceiver unit connection between the two antennas according to which connection yields the better signal quality (least signal loss). Alternatively, the DSP can combine the signals from both antennas 302 and 308 for connection to the transceiver unit 218.

Figure 5 depicts a block diagram of a mobile station 500 that can make use of the disclosed embodiments. The mobile station 500 includes, in this example:

A control head 502 containing an audio interface, i.e. a speaker 504 and microphone 506. The control head 502 generally includes a display assembly 508 allowing a user to see dialed digits, stored information, messages, calling status information, including signal strength, etc. The control head generally includes a keypad 510, or other user control device, allowing a user to dial numbers, answer incoming calls, enter stored information, and perform other mobile station functions. The control head also has a controller unit 534 that interfaces with a logic control assembly 518 responsible, from the control unit perspective, for receiving commands from the keypad 510 or other control devices, and providing status information, alerts, and other information to the display assembly 508;

A transceiver unit 512 containing a transmitter unit 514, receiver unit 516, and the logic control assembly 518. The transmitter unit 514 converts low-level audio signals from the microphone 506 to digital coding using a codec (a data coder/decoder) 520. The digitally encoded audio is represented by modulated shifts, for example, in the frequency domain, using a shift key modulator/demodulator 522. Other codes transmission utilized by the logic control assembly 518, such as station parameters and control information, may also be encoded for transmission. The modulated signal is then amplified 524 and transmitted via an antenna assembly 526;

The antenna assembly 526 contains a TR (transmitter/receiver) switch 536 to prevent simultaneous reception and transmission of a signal by the mobile station 500. The transceiver unit 512 is connected to the antenna assembly 526 through the TR switch 536. The antenna assembly contains at least one antenna 538. The antennas described in the

disclosed embodiments 208, 302, and 308) and the antenna switch (or DSP) are part of the antenna assembly of the described mobile station;

5 The receiver unit 516 receives a transmitted signal via the antenna assembly 526. The signal is amplified 524 and demodulated 522. If the signal is an audio signal, it is decoded using the codec 520. The audio signal is then reproduced by the speaker 504. Other signals are handled by the logic control assembly 518 after demodulation 522; and

10 A logic control assembly 518 usually containing an application specific integrated circuit (or ASIC) combining many functions, such as a general purpose microprocessor, digital signal processor, and other functions, into one integrated circuit. The logic control assembly 518 coordinates the overall operation of the transmitter and receiver using control messages. The various disclosed embodiments make use of the logic control assembly to control scanning and evaluation of other base stations. Generally, the logic control assembly operates from a program that is stored in flash memory 528 of the mobile station.

15 Flash memory 528 allows upgrading of operating software, software correction or addition of new features. Flash memory 528 is also used to hold user information such as speed dialing names and stored numbers. The various disclosed embodiments typically function from this or another section of the mobile station's memory.

20 In addition to flash memory 528, the mobile station will typically contain read only memory (ROM) 530 for storing information that should not change, such as startup procedures, and random access memory (RAM) 532 to hold temporary information such as channel number and system identifier.

25 As will be recognized by those skilled in the art, the innovative concepts described in the present application can be modified and varied over a tremendous range of applications, and accordingly the scope of patented subject matter is not limited by any of the specific exemplary teachings given.

30 For example, the disclosed embodiments have been described in the context of a wireless mobile station without using a specific protocol. However, any wireless communications protocols, for example, IS-95, IS-136, CDMA2000, and TDMA, can take advantage of the disclosed embodiments.

35 For another example, the disclosed embodiments have been described in the context of a single mode, wireless mobile station. However, multi-mode mobile stations may take advantage of the disclosed embodiments as well. Multi-mode mobile stations may require microstrip antennas with differing tap points for differing modes. Therefore, slight

modifications for connection of the multi-mode antenna to the transceiver unit may have to be made.

5 For another example, the disclosed embodiments have been described in the context of a single band, wireless mobile station. However, multi-band mobile stations may also take advantage of the disclosed embodiments. Multi-band mobile stations may require microstrip antennas with differing tap points and lobe configurations for differing bands. Therefore, slight modifications for connection of the multi-band antenna to the transceiver unit may have to be made.

10 For another example, the disclosed embodiments have been described in the context of a mobile station with a movable casing portion which covers the keyboard. However, a movable casing portion can cover more or less of the mobile station than is depicted in the Figures. Furthermore, the casing can be manufactured such that its movable portion does not necessarily cover the keyboard at all. For instance, a movable portion for the casing containing an antenna can slide either up or down, from the back or  
15 side of the mobile station, or from a middle section of the mobile station bounded by stationary front and back sections.

Claims

What is claimed is:

- 1       1.     A mobile station, comprising:  
2             a movable-type casing including, at least:  
3                 a control head;  
4                 a transceiver unit, at least partially controlled by said control head; and  
5                 an antenna assembly connected to said transceiver unit, comprising,  
6                 an antenna having first and second tap points;  
7                 wherein when said casing is opened, said transceiver unit is switched from  
8                 said first tap point to said second tap point.
  
- 1       2.     The mobile station of Claim 1, wherein said casing further includes a moveable  
2             portion and a stationary portion, and said casing is opened by sliding a movable portion of  
3             said casing away from a stationary portion of said casing.
  
- 1       3.     The mobile station of Claim 1, wherein said casing further includes a moveable  
2             portion and a stationary portion, and said casing is opened by flipping a movable portion of  
3             said casing away from a stationary portion of said casing.
  
- 1       4.     The mobile station of Claim 1, wherein said is an internal antenna.
  
- 1       5.     The mobile station of Claim 1, wherein said antenna is an electrically symmetrical  
2             microstrip antenna.
  
- 1       6.     The mobile station of Claim 1, further comprising a stationary connector to switch  
2             said transceiver unit from said first antenna tap point to said second antenna tap point.
  
- 1       7.     The mobile station of Claim 1, wherein said antenna is in a movable portion of the  
2             casing of said mobile station.

- 1 8. A mobile station, comprising:  
2 a movable-type casing including at least,  
3 a control head;  
4 a transceiver unit, at least partially controlled by said control head; and  
5 an antenna assembly connected to said transceiver unit, comprising,  
6 a first antenna; and  
7 a second antenna;  
8 wherein when said casing is opened, said transceiver unit is switched from said first  
9 antenna to said second antenna.
- 1 9. The mobile station of Claim 8, wherein said casing further includes a moveable  
2 portion and a stationary portion, and said casing is opened by sliding a movable portion of  
3 said casing away from a stationary portion of said casing.
- 1 10. The mobile station of Claim 8, wherein said casing further includes a moveable  
2 portion and a stationary portion, and said casing is opened by flipping a movable portion of  
3 said casing away from a stationary portion of said casing.
- 1 11. The mobile station of Claim 8, wherein said antennas are internal to said casing.
- 1 12. The mobile station of Claim 8, wherein at least one of said antennas is a microstrip  
2 antenna.
- 1 13. The mobile station of Claim 8, further comprising an antenna switch connected to  
2 said first and second antennas, said antenna switch switching said transceiver unit between  
3 said first and second antennas.
- 1 14. The mobile station of Claim 8, further comprising a digital signal processor connected  
2 to said first and second antennas, said digital signal processor switching said transceiver  
3 unit between said first and second antennas.
- 1 15. The mobile station of Claim 8, wherein at least one of said antennas is in a movable  
2 portion of the casing of said mobile station.

1 16. The mobile station of Claim 8, further comprising a digital signal processor connected  
2 to said first and second antennas, wherein said digital signal processor dynamically switches  
3 between said antennas when said mobile station is on.

1 17. A mobile station, comprising:  
2 a casing with movable and stationary portions;  
3 an antenna fixed in said movable portion of said casing; and  
4 an antenna connector fixed in said stationary portion of said casing;  
5 wherein said antenna connector connects said antenna to a transceiver unit at a first  
6 tap point if said casing is closed and said antenna connector connects said antenna  
7 to said transceiver unit at a second tap point if said casing is opened.

1 18. The mobile station of Claim 17, wherein said antenna is an electrically symmetrical  
2 microstrip antenna.

1 19. A mobile station, comprising:  
2 a casing with movable and stationary portions;  
3 an antenna fixed in said movable portion of said casing; and  
4 a transceiver unit connected to said antenna;  
5 wherein said antenna is connected to said transceiver unit at a single tap point and  
6 said antenna can be moved to minimize signal loss during use.

1 20. The mobile station of Claim 19, wherein said antenna is a microstrip antenna.

1 21. A mobile station, comprising:  
2 a casing with movable and stationary portions;  
3 at least one antenna fixed in said movable portion of said casing;  
4 at least one other antenna; and  
5 an antenna switch connected to said antennas;  
6 wherein said antenna switch selectively connects at least one of said antennas to a  
7 transceiver unit of said mobile station if said casing is opened.

1 22. The mobile station of Claim 21, wherein at least one of said antennas is a microstrip  
2 antenna.

1 23. The mobile station of Claim 21, wherein said antenna switch comprises a digital  
2 signal processor.

1 24. The mobile station of Claim 21, wherein said antenna switch comprises a digital  
2 signal processor which can dynamically switch between said antennas when said mobile  
3 station is on.

1 25. A method of constructing a mobile station, comprising the steps of:  
2 fixing an antenna in the casing of a mobile station; and  
3 positioning an antenna connector in said casing of said mobile station;  
4 wherein the tap point of said antenna changes if said casing is opened.

1 26. The method of Claim 25, wherein said antenna is an electrically symmetrical  
2 microstrip antenna.

1 27. The method of Claim 25, wherein said antenna connector is positioned in a stationary  
2 portion of said casing of said mobile station.

1 28. The method of Claim 25, wherein said antenna is fixed in a movable portion of said  
2 casing of said mobile station.

1 29. A method of constructing a mobile station, comprising the steps of:  
2 fixing at least two antennas in the casing of a mobile station; and  
3 connecting said antennas to an antenna switch;  
4 wherein said antenna switch selectively connects at least one of said antennas to a  
5 transceiver unit of said mobile station if said casing of said mobile station is opened.

1 30. The method of Claim 29, wherein said antenna switch comprises a digital signal  
2 processor.

1 31. The method of Claim 29, wherein said antenna switch comprises a digital signal  
2 processor which can dynamically connect at least one of said antennas to a transceiver unit  
3 of said mobile station when said mobile station is on.

1 32. The method of Claim 29, wherein at least one of said antennas is in a movable  
2 portion of said casing of said mobile station.

1 33. The method of Claim 29, wherein at least one of said antennas is in a stationary  
2 portion of said casing of said mobile station.

1 34. The method of Claim 29, wherein at least one of said antennas is a microstrip  
2 antenna.



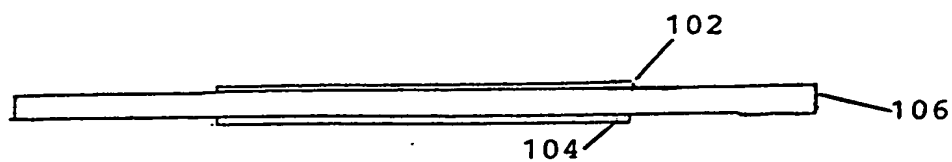


Figure 1  
(Prior Art)

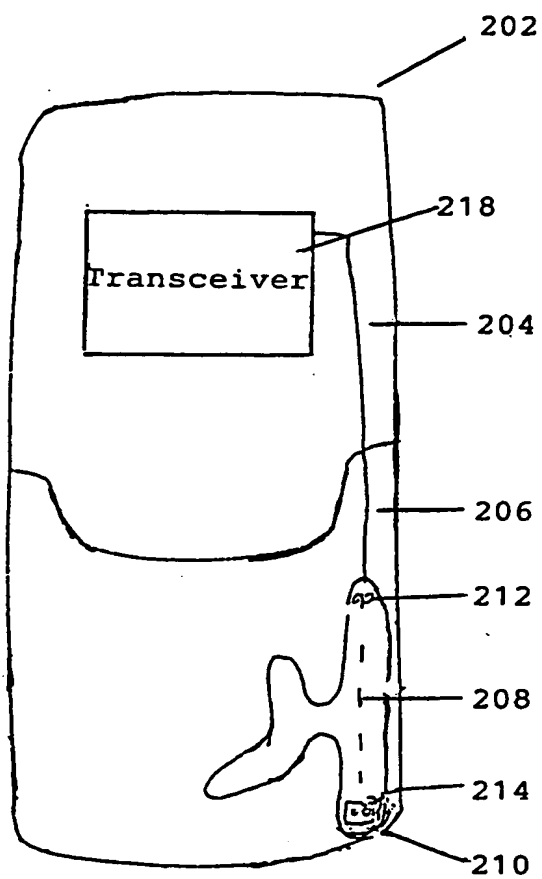


Figure 2A

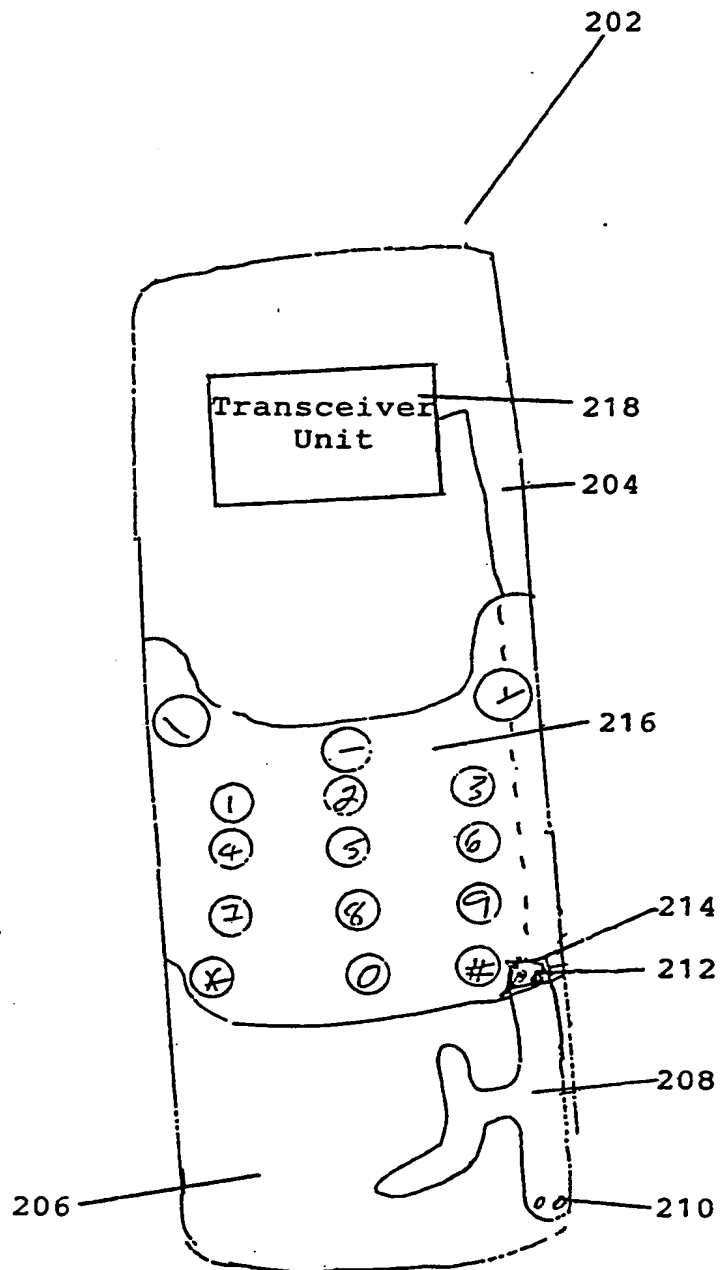


Figure 2B

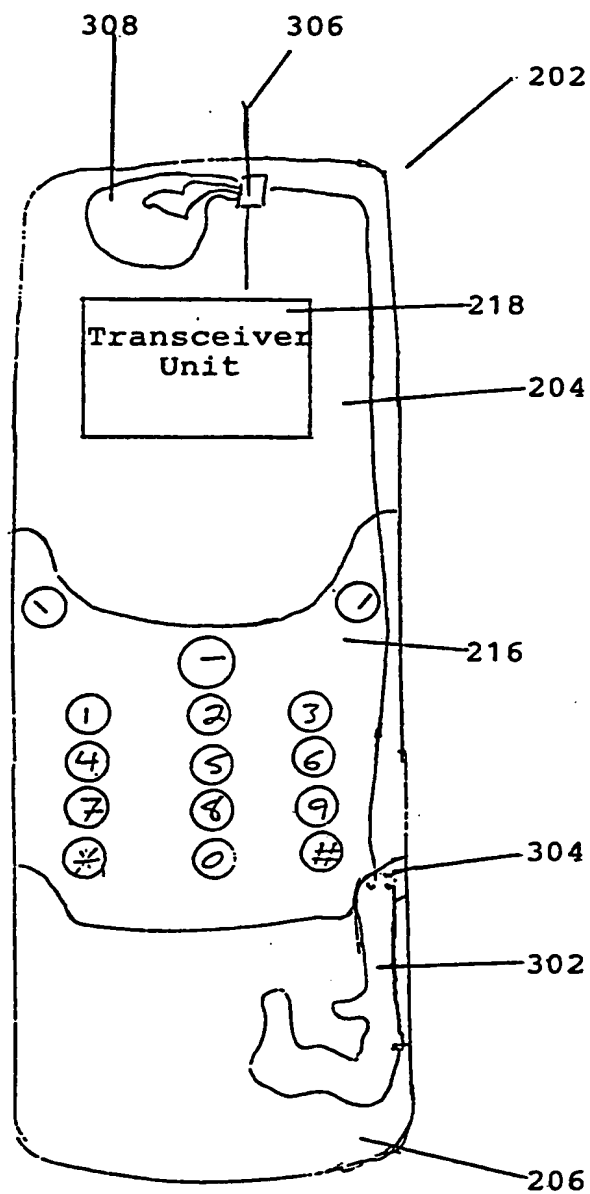


Figure 3

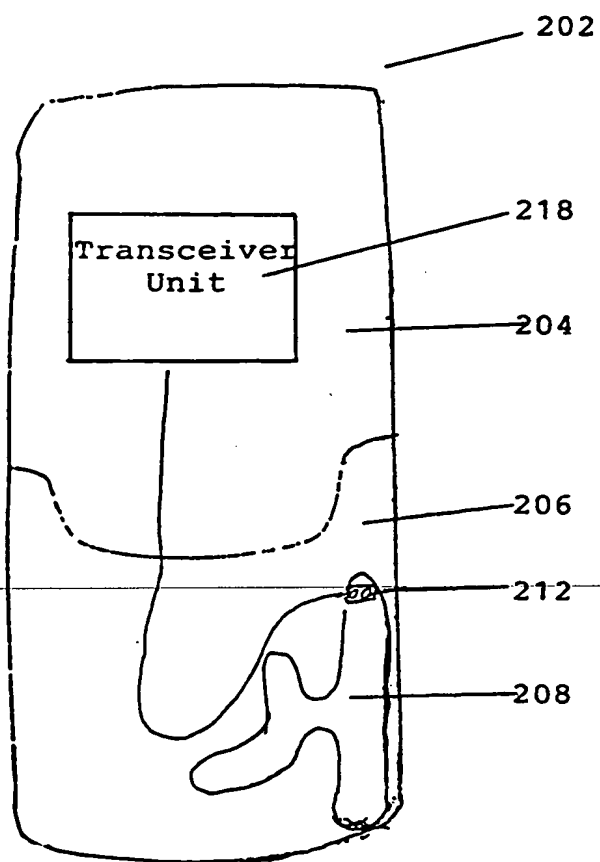


Figure 4

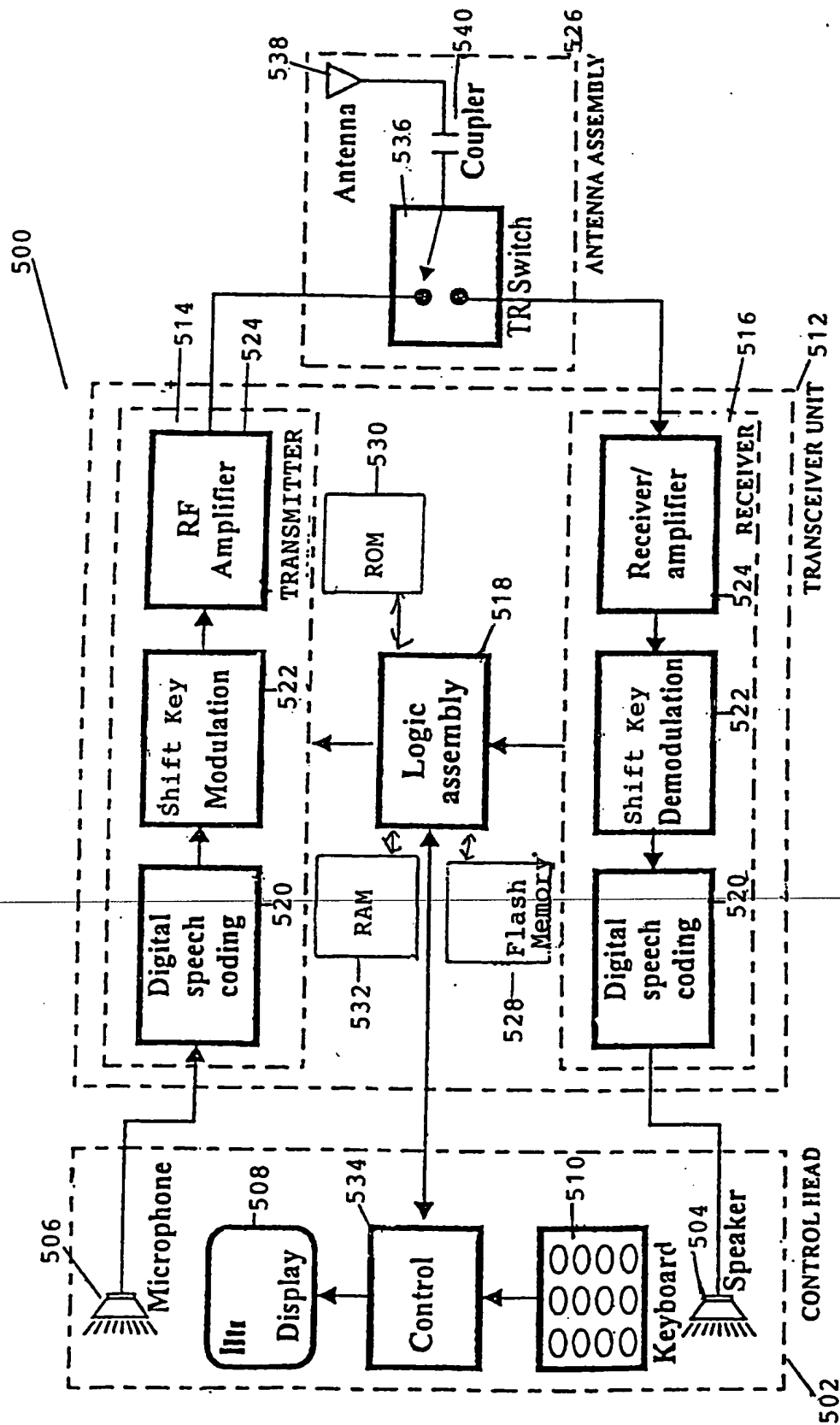


Figure 5

# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/US 00/12295

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01Q1/24 H01Q1/08 H01Q3/24 H04B1/38 H04M1/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01Q H04B H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 09163 A (UNIVERSAL CELLULAR) 29 May 1992 (1992-05-29)	1, 17, 19, 25
Y	page 5, line 30 -page 6, line 37; figures 5, 6	8, 21, 29
X	WO 98 09414 A (BELLSOUTH ) 5 March 1998 (1998-03-05)	1, 17, 19, 25
Y	page 7, line 34 -page 8, line 37 page 12, line 20 -page 14, line 28; figures 1-9	8, 21, 29
Y	US 4 538 153 A (TAGA) 27 August 1985 (1985-08-27) abstract; figures 1-3A, 5A, B	8, 21, 29
	-/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

4 August 2000

Date of mailing of the international search report

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Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

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**Internal Application No**

**PCT/US 00/12295**

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 197 23 331 A (BOSCH) 10 December 1998 (1998-12-10) column 3, line 6 -column 4, line 39; figures 1-3	1-34
A	EP 0 508 567 A (SHAYE COMMUNICATIONS) 14 October 1992 (1992-10-14) column 2, line 17 -column 3, line 47; figures 1-6	1-34
A	US 5 752 204 A (EPPERSON ET AL.) 12 May 1998 (1998-05-12) column 6, line 47 -column 8, line 51; figures 2-6	1-34
A	DE 42 02 383 A (LOEWE OPTA) 5 August 1993 (1993-08-05) column 2, line 25 -column 3, line 56; figure	1-34



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information on patent family members

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